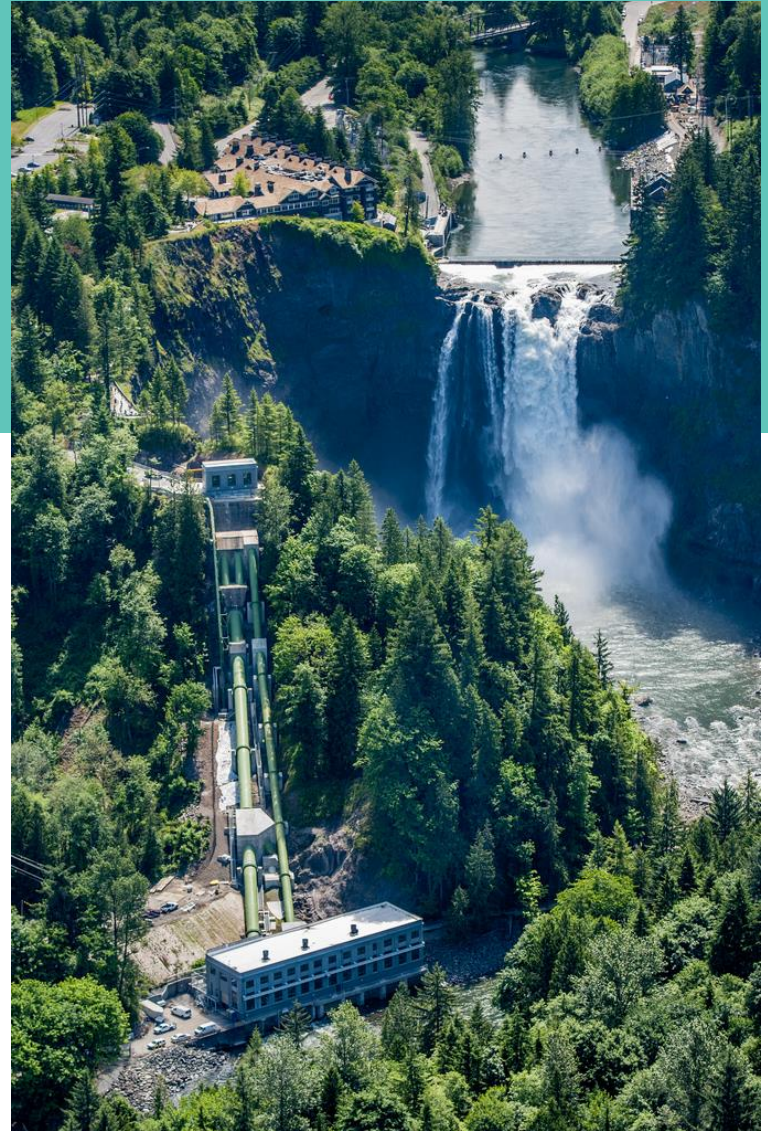


Snoqualmie Falls

Redevelopment Project;
Conforming to New License
Requirements; and
Maximizing Efficiency

Dave Bruce, PE

Snoqualmie Falls Plant Engineer



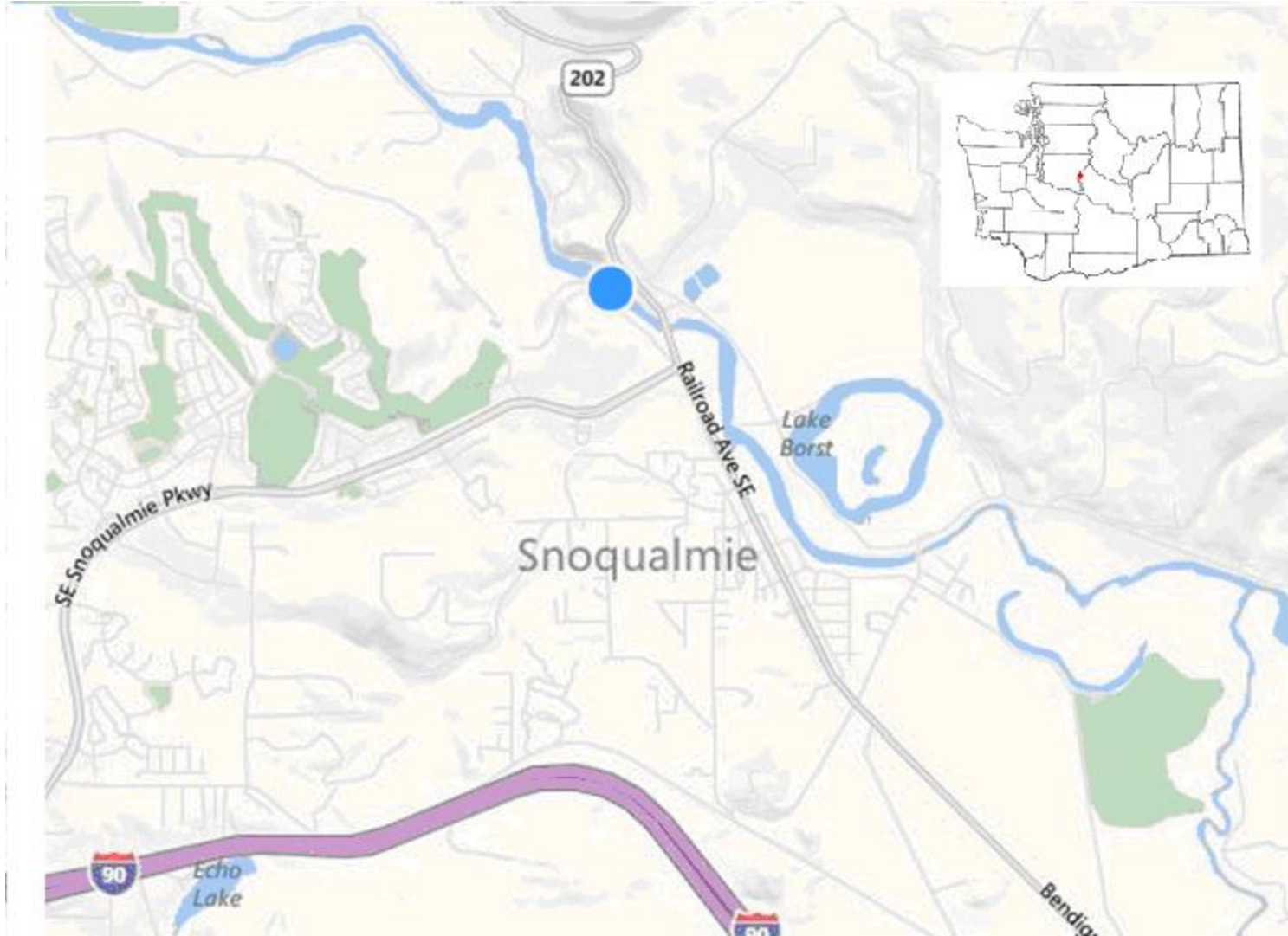
5/21/2014

Snoqualmie Falls

OUTLINE

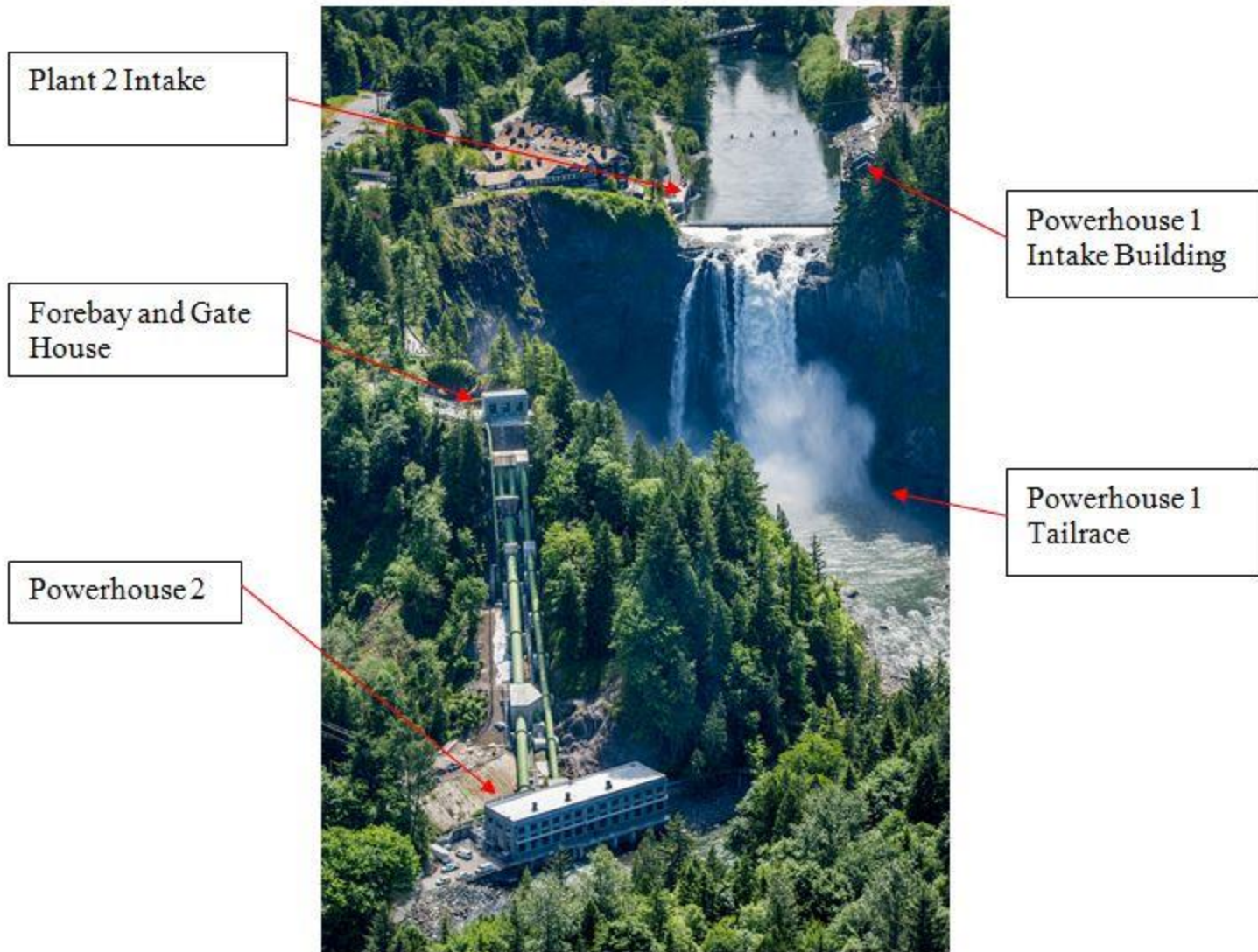
- Introduction
- Plant History
- Redevelopment Project Scope
- Snoqualmie After the Rebuild
- FERC License Requirements
- Facility Controller

Introduction

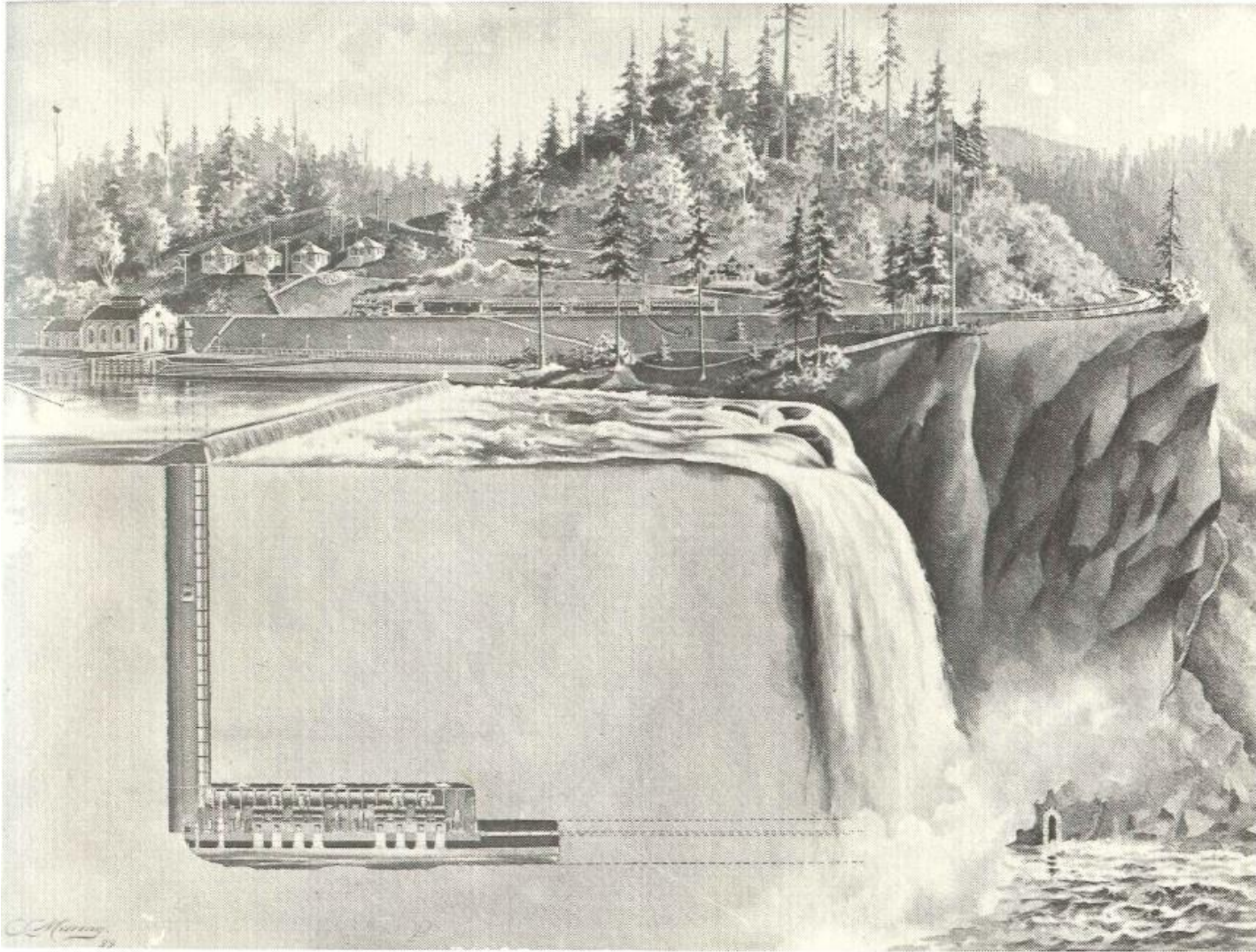


Google Maps

Introduction



Introduction



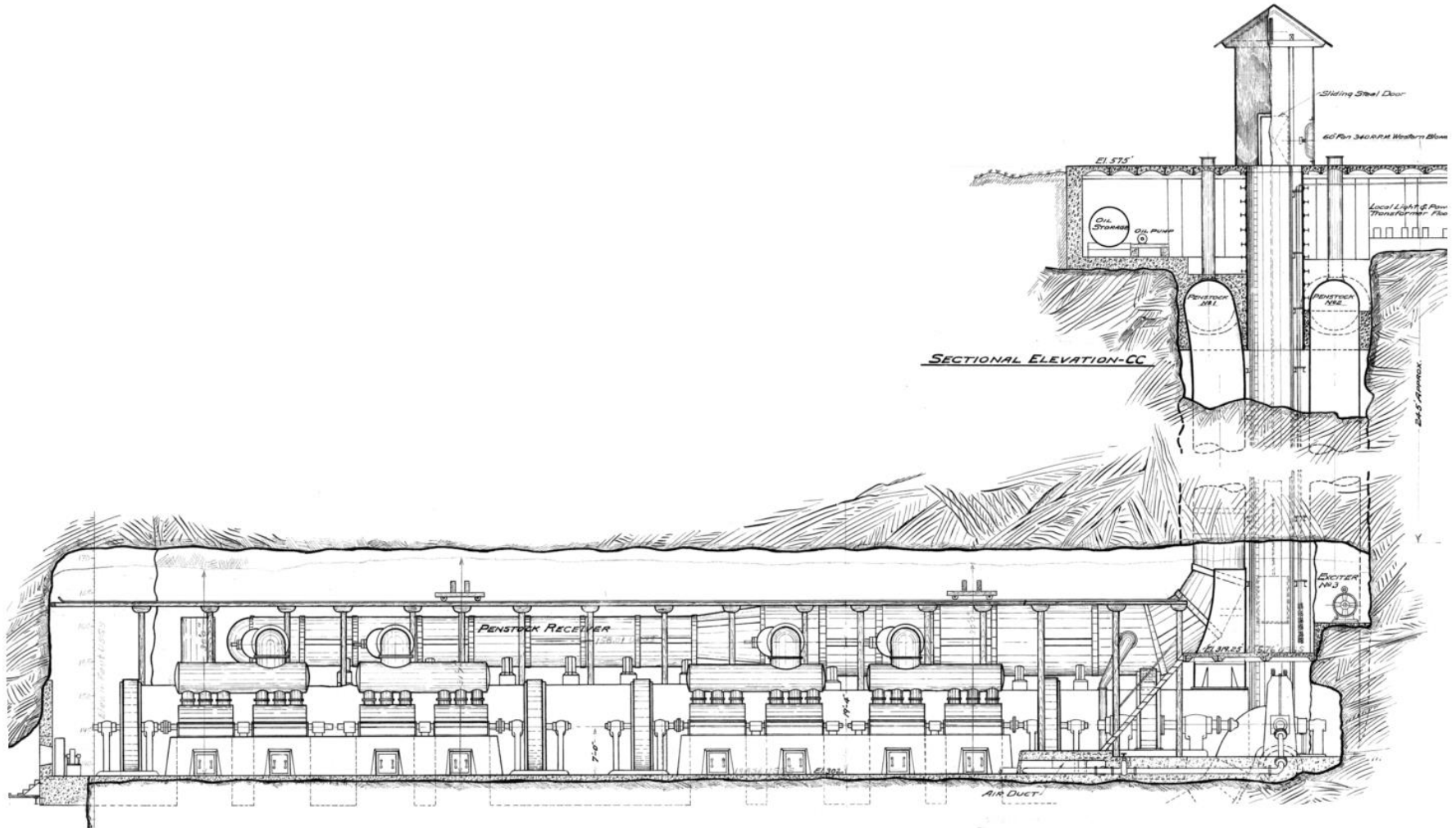
Plant 1

History

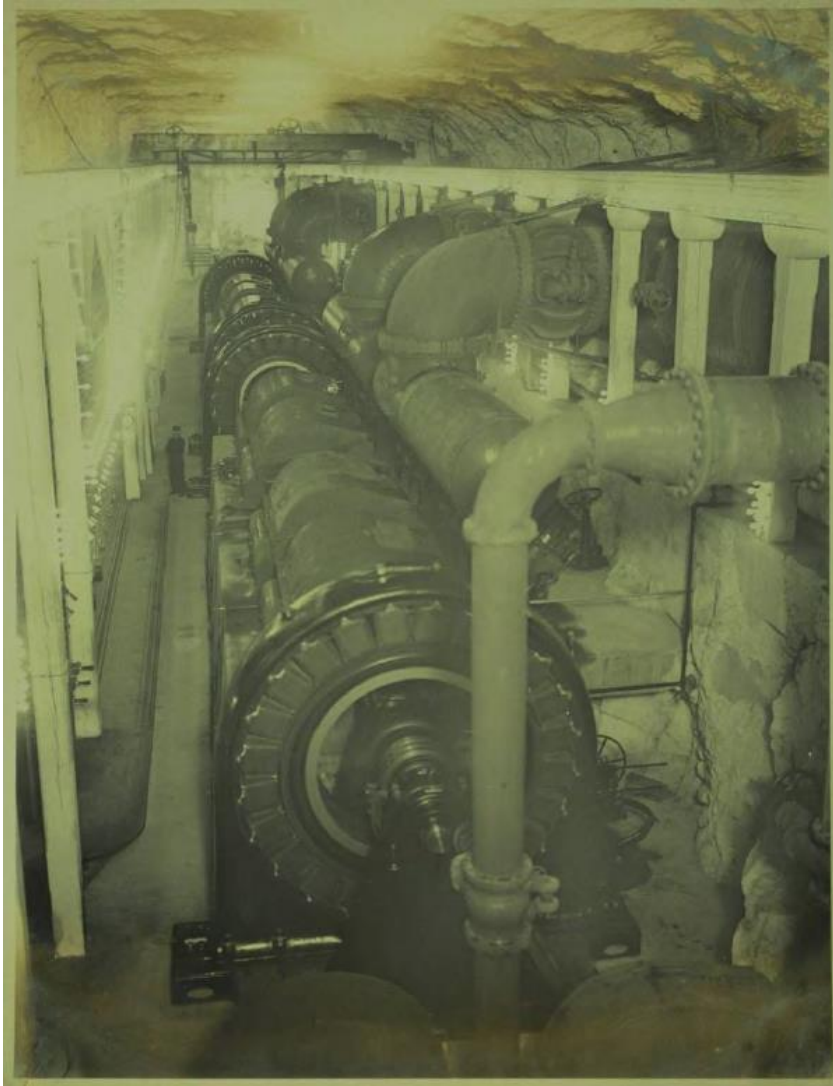
- Charles H. Baker began construction of Powerhouse 1 in 1898 and completed the project in 16 months later.
- First completely underground powerhouse in the world.
- Units 1-4; Each 1.5 MW, rotating armature, three phase, AC generators (1898)
- 1905 – Added unit 5 (Horizontal Francis Turbine, 5MW)

History

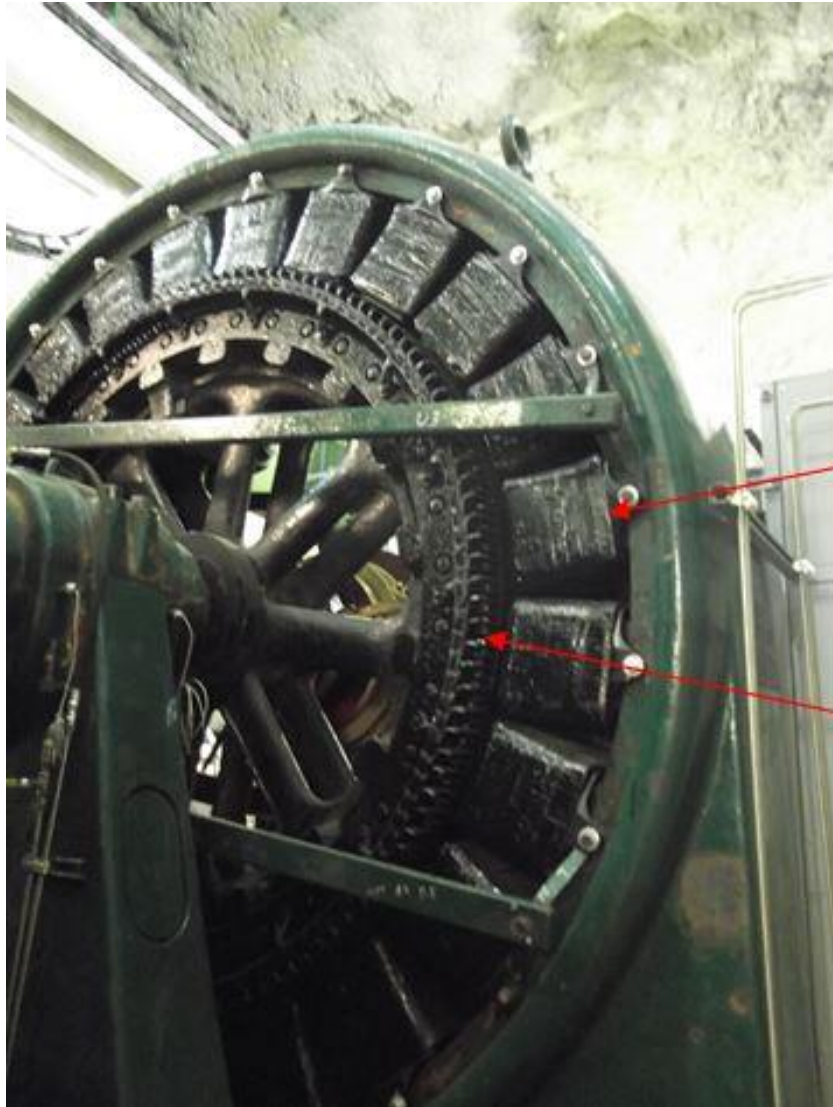
Power House #1.



History



History



Stationary Poles
(Field)

Rotating
Armature

3 Phase Slip Rings



History

Power House #1 Intake Building Completed



PUGET SOUND ENERGY
The Energy To Do Great Things

History

1910 - Addition of Power House 2 (Unit 6)



History

1957 – Unit 7 installed



Redevelopment Project Scope

- Replace unit 5 and 6 (new runner and generator).
- Governor replacement Unit 1-6.
- Static excitation replacement Units 1-7.
- Protection and metering all units.
- Vibration monitoring all units
- New control system for the facility. (unit, plant, and facility controllers)
- Bypass valves at Plant 2 to offset flow in the river.
- Bypass valve at P1 to maintain 30 CFS in the cavity.

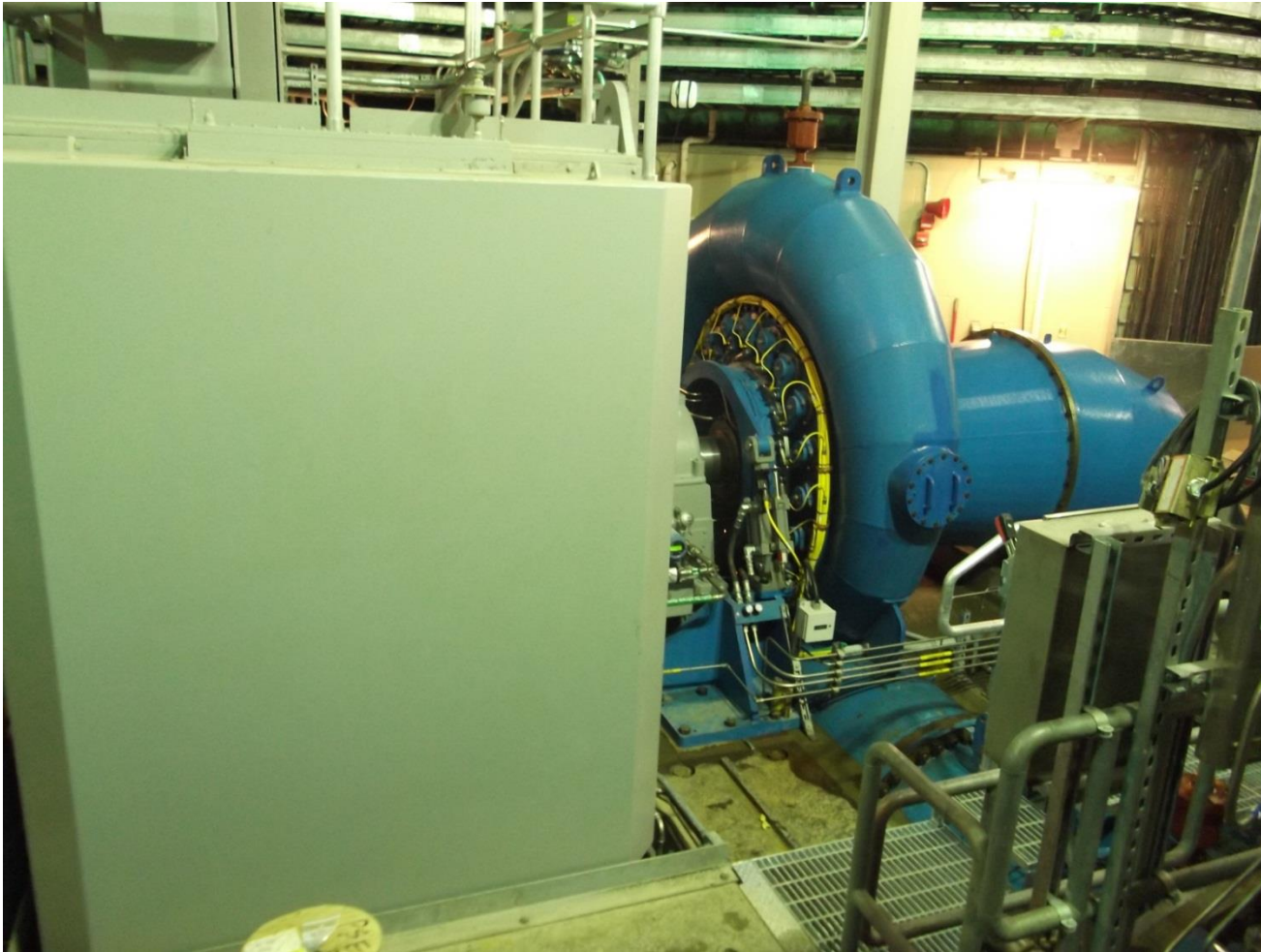
Snoqualmie After the Rebuild

- Plant 1



Snoqualmie After the Rebuild

- Unit 5 (new)



Snoqualmie After the Rebuild

- Plant 1 Intake Building (new)



Snoqualmie After the Rebuild

- Plant 2 Powerhouse and Penstocks



Snoqualmie After the Rebuild

- Unit 7 (existing) and Switchgear (new)



Snoqualmie After the Rebuild

- Unit 6 (new)



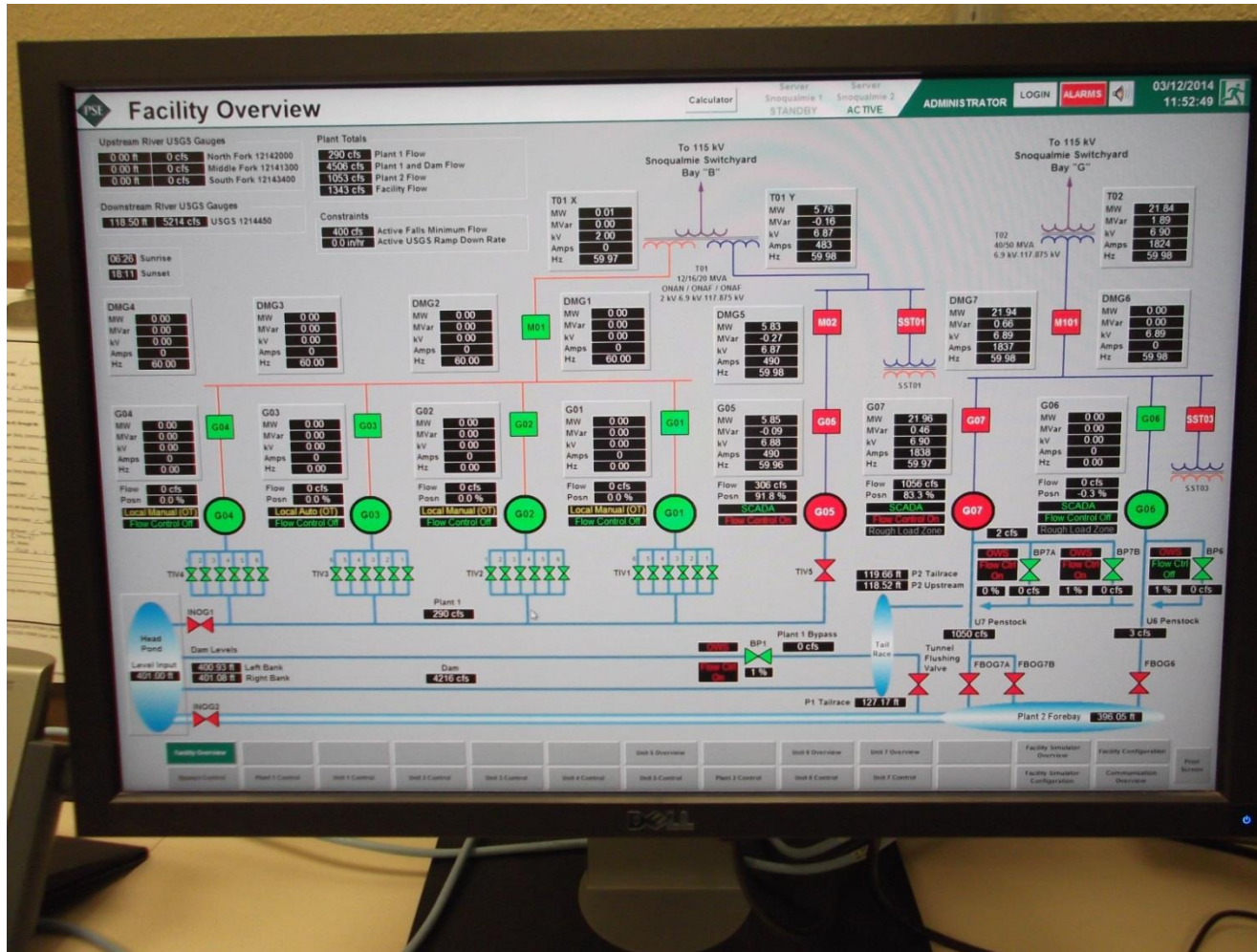
Snoqualmie After the Rebuild

- Plant 2 Bypass Valves (new)



Snoqualmie After the Rebuild

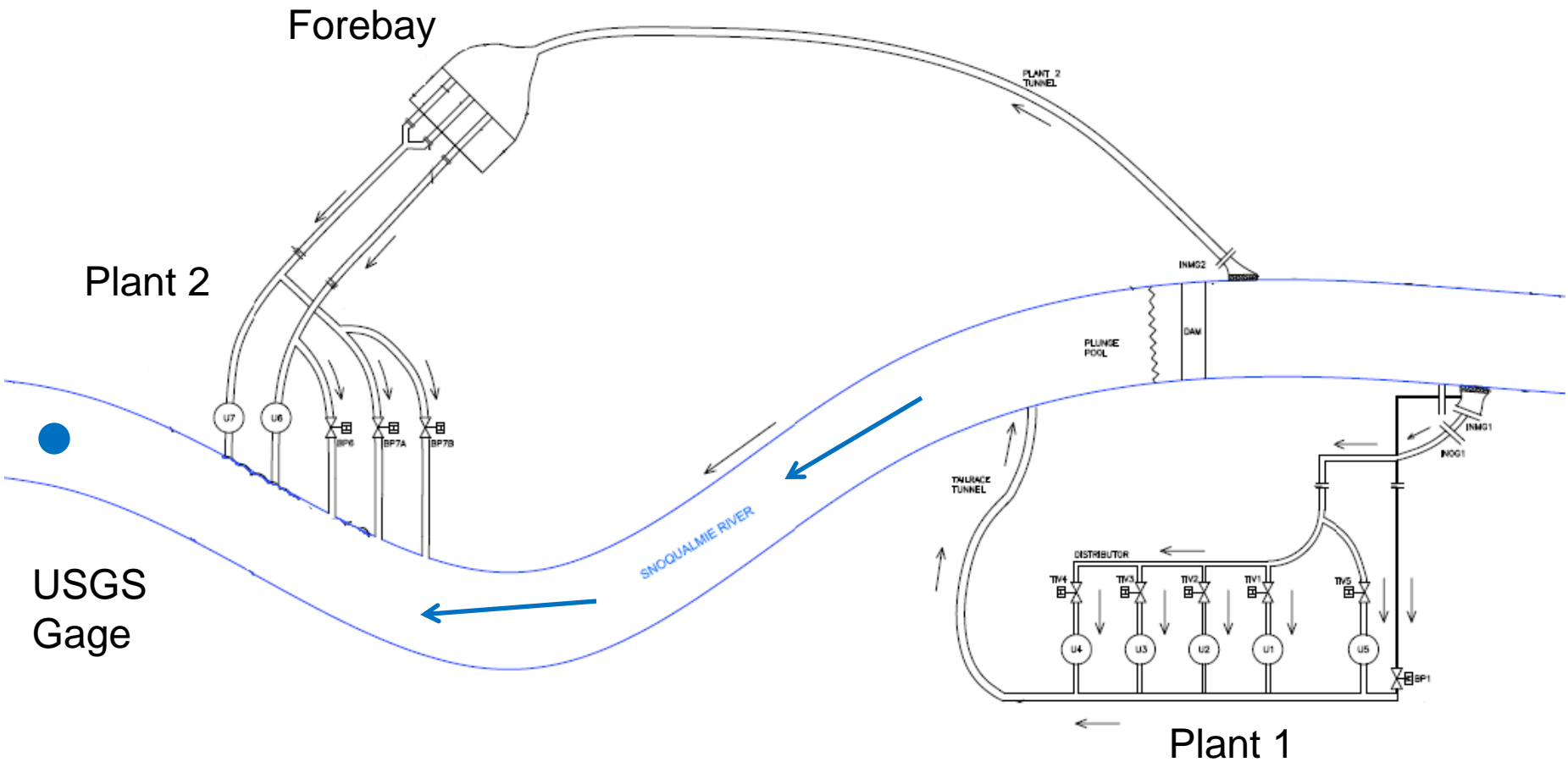
- Operator Work Station (new)



FERC License Requirements

- 2500 Cubic Feet Per Second (CFS) - maximum facility flow
 - 700 CFS – Plant 1
 - 1800 CFS – Plant 2
- Maintain >30 CFS through Plant 1 at all times.
- Maintain >300 CFS in the plunge pool (or natural flow)
 - Plunge pool = plant 1 flow + falls flow

FERC License Requirements



FERC License Requirements

- Minimum Fall Flow

Date	Day Time (cfs)	Night Time (cfs)
May 1 - June 30	1000	1000
July 1 - August 31	100 - weekdays 200 – weekends & holidays	25 - weekdays 200 – weekends & holidays
Sep 1 - April 30	100 200 – Labor Day weekend only	25 200 – Labor Day weekend only

FERC License Requirements

- Ramp Down Rates (Only applicable <3000 CFS in the river)

Date	Day Time Rate	Night Time Rate
Feb. 16 – June 15	No Ramping	2 in/hr
June 16 – Oct. 31	1 in/hr	1 in/hr
Nov. 1 – Feb. 15	2 in/hr	2 in/hr

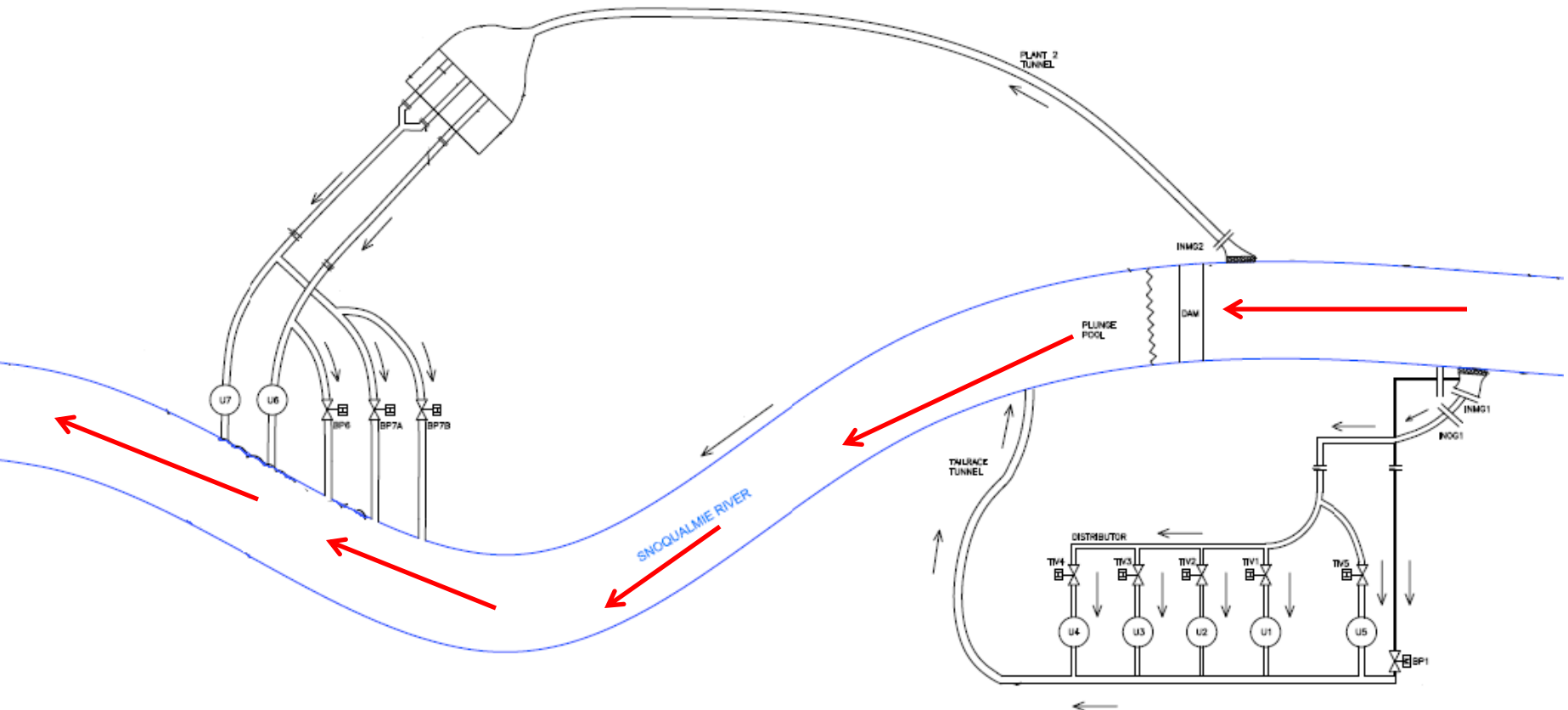
Facility Controller



1. Compliance
2. Maximize generation

Facility Controller

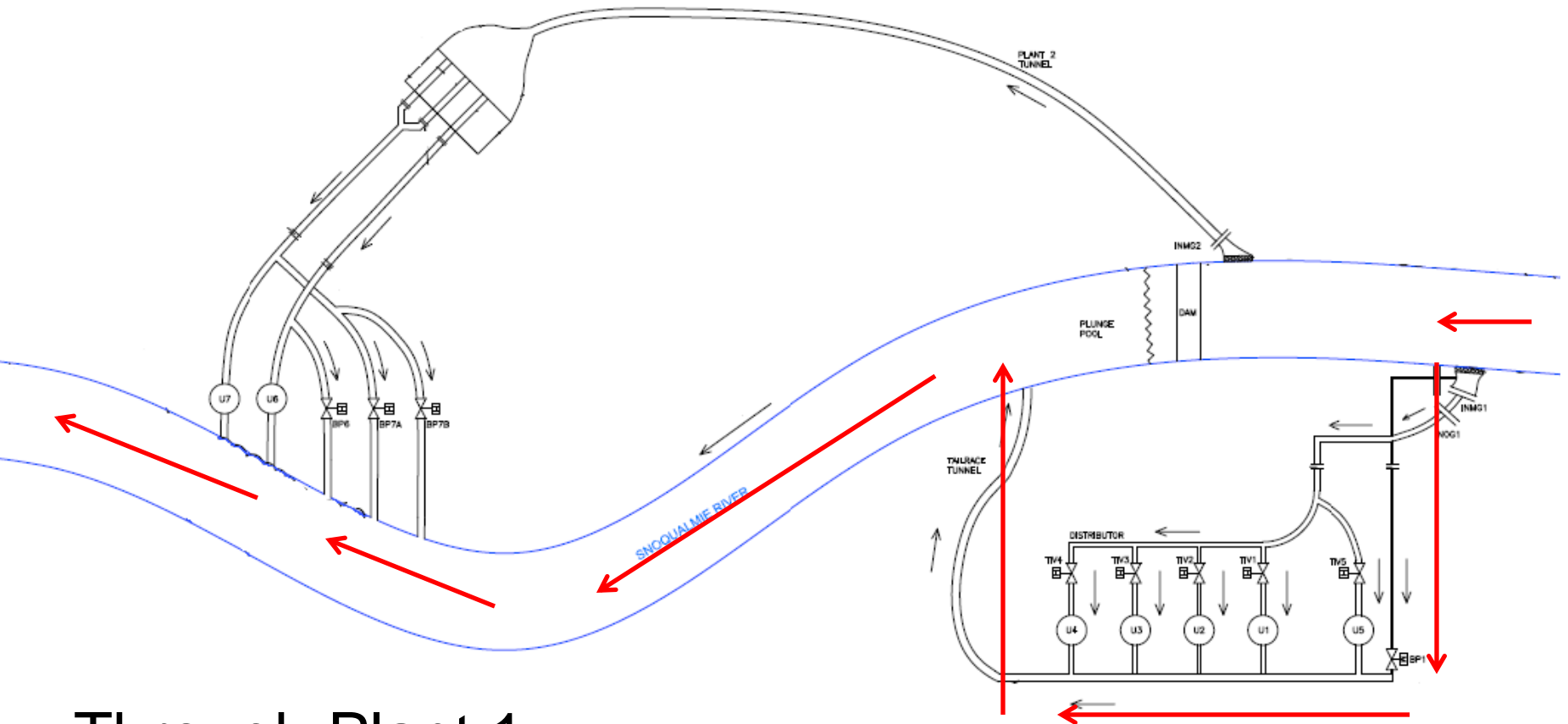
Water Transit Times



Over The Falls

Facility Controller

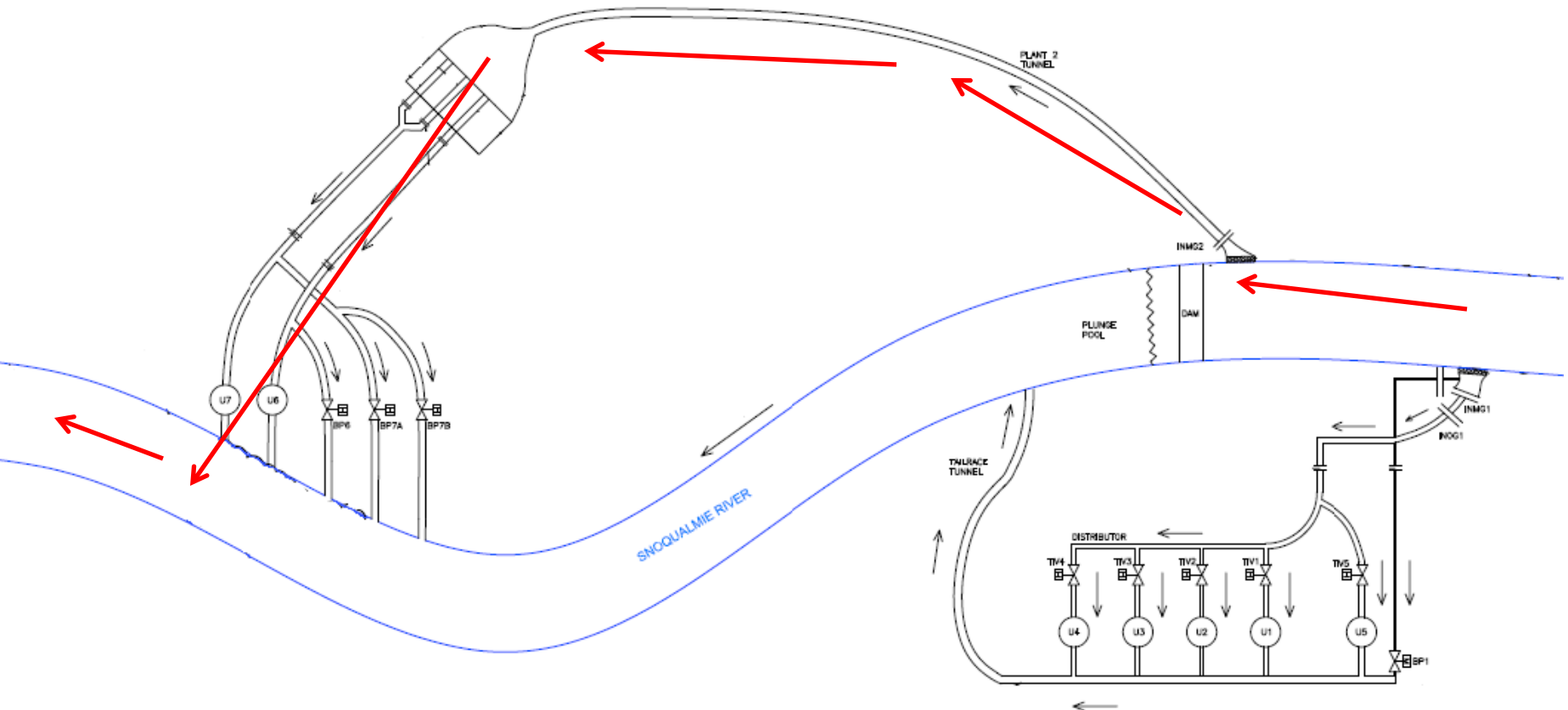
Water Transit Times



Through Plant 1

Facility Controller

Water Transit Times



Through Plant 2

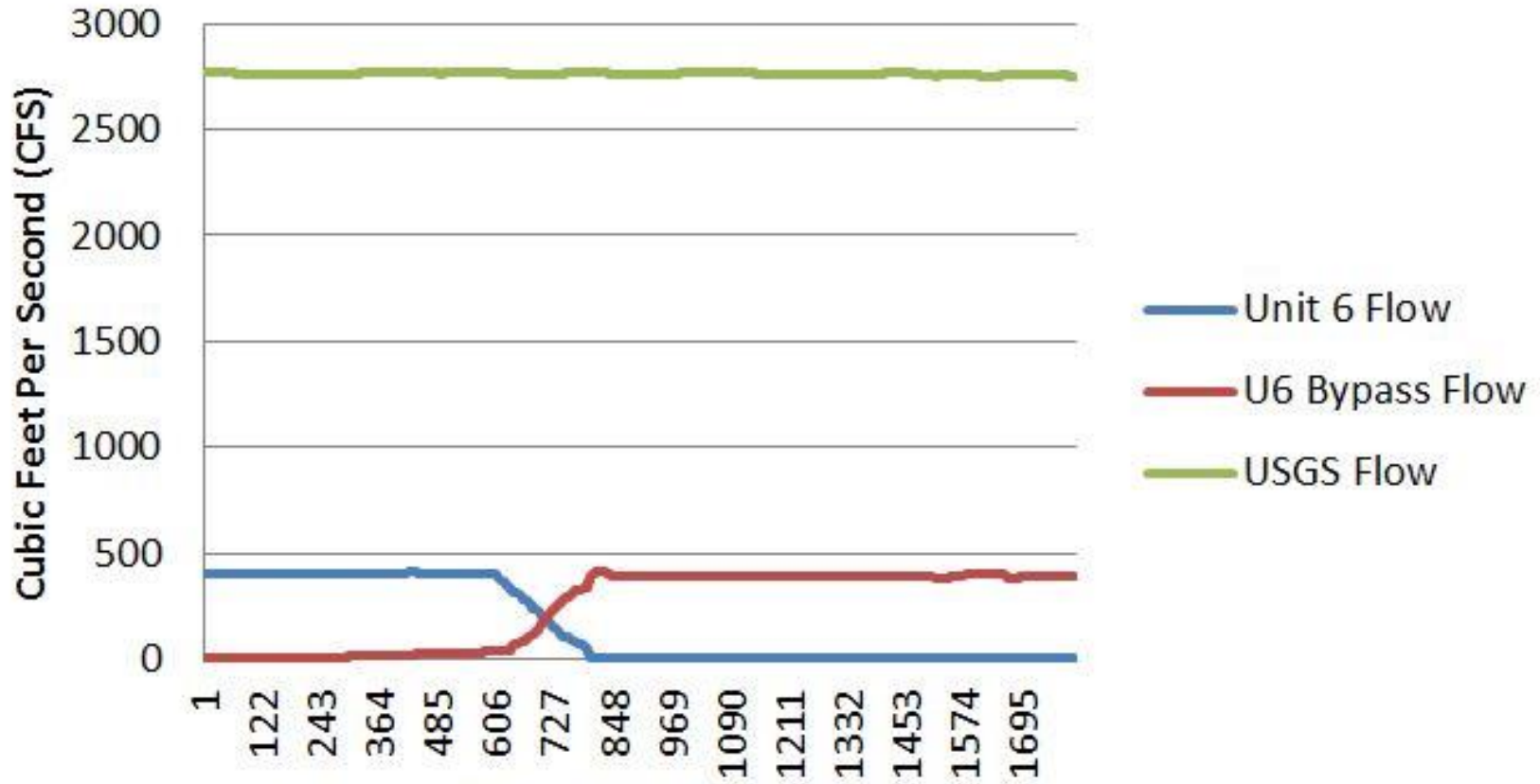
Facility Controller

- Over the falls ~ 25 minutes
- Through Plant 1 ~ 17 minutes
- Through Plant 2 ~ 13 minutes

Transit times increase with higher flows and decrease with lower river flows.

Facility Controller

U6 Transfer

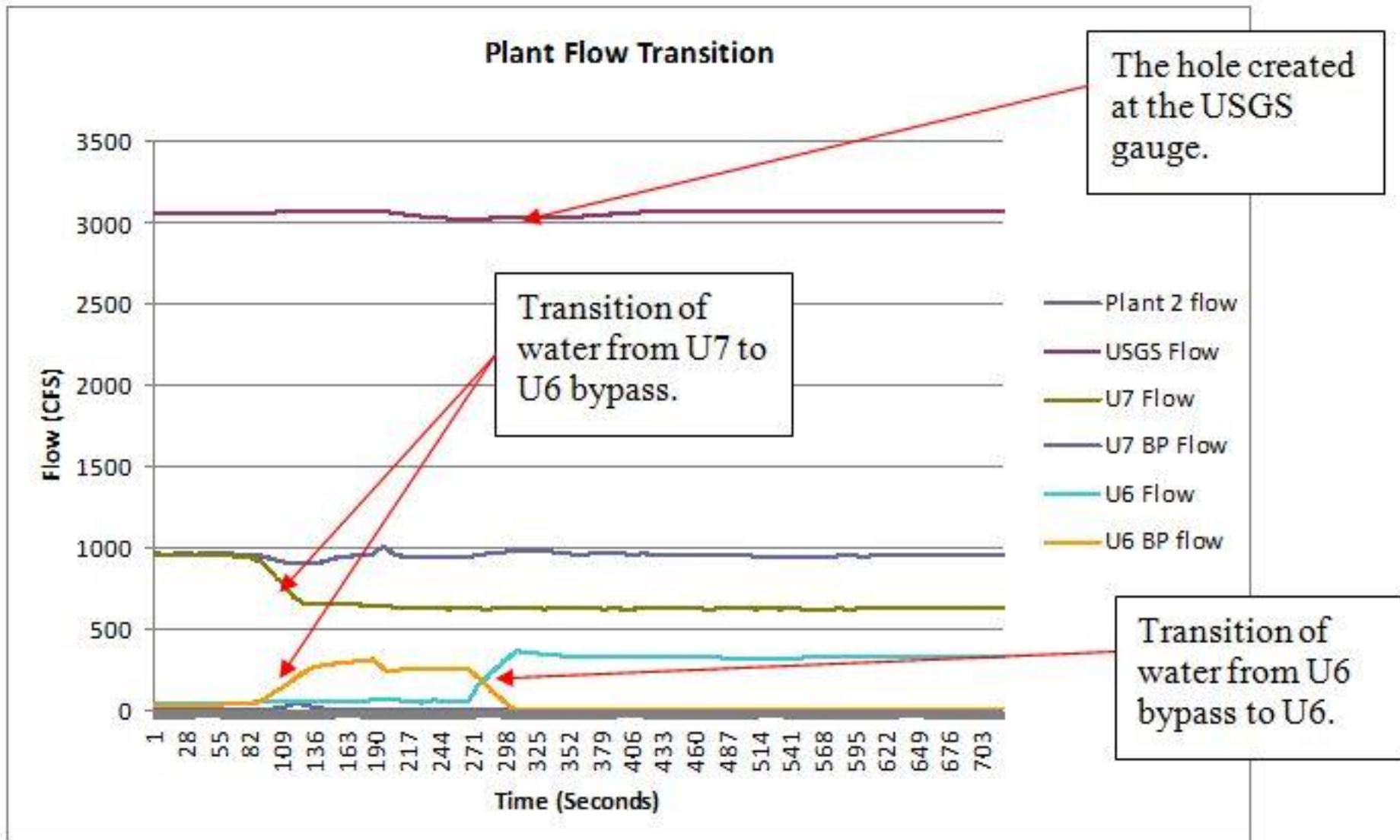


Facility Controller



Unit 7 Rough Load Zone Table

Facility Controller



Facility Controller

- Optimization
 - Unit optimization calculation
 - Comparing CFS vs. Power output for each unit
 - Using Hills curves; head; pipe flow loss
 - Plant optimization calculation
 - Compares each unit combination in 5 CFS increments.

Unit 6	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Unit 7	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

- Facility optimization calculation
 - Compares each plant combination in 5 CFS increments.

Plant 1	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Plant 2	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

Conclusion

- Many one of a kind challenges.
- Facility controller commissioning ongoing.
- Water transition times are being tuned.
- Next milestone will be operations with all 7 units.

QUESTIONS???

